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Climate change mitigation and adaptation strategies in drylands of Northern Karnataka

RAVI DUPDAL[1]*, B L PATIL[2], B L MANJUNATHA[3] and S L PATIL[1]

ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Ballari, Karnataka 583 104, India

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ABSTRACT

This study was carried out in Vijayapura and Bagalkot districts of Karnataka to assess the adoption of improved technologies by dryland farmers to mitigate effects of climate change. Primary data was collected from 240 farmers using multi-stage random sampling technique. Nearly 70% farmers experienced the decreased and uneven distribution of rainfall, 35% farmers experienced untimely rainfall and 48% farmers experienced increase in temperature. This unpredictable variation in climate especially rainfall and temperature resulted in decreased crop yields, frequent crop failures, sinking water level in bore wells and open wells and increased emergence of pest and diseases. The farmers in the region sustained crop yields by adopting climate resilience indigenous and modern scientific technologies like manipulating sowing dates, mixed farming, crop diversification, alternate cropping systems and drought tolerant varieties.The age of farmer, access to irrigation, level of education, farming experience, social participation, land holding size, livestock possession and institutional credit had significant impact on adoption of climate resilient technologies by the farmers in the region.

Keywords: Climate, Crop yields, Dryland, Mitigation, Sustainability

Climate change is a complicated and challenging environmental problem faced by world today and is increasingly recognized as a threat to agriculture and food security. The impact of climate change is felt more by the farmers in the tropical areas, especially in developing countries, including India (Rao *et al.* 2010). India is vulnerable to the adverse impact of climate change due to poor socio-economic, demographic and institutional adversaries (Dupdal and Patil 2019). Earlier studies on climate change predicted that unexpected change in temperature and rainfall significantly reduced agriculture production. This impact is severe in rainfed areas (67%) in India thus making agricultural sector sensitive to change in the rainfall pattern (Agarwal *et al.* 2010). The adaptation and coping mechanisms to climate change are critical in developing countries like India. Earlier studies have revealed that with adaptation, the risk to climate change is reduced or minimized to a greater extent in agricultural sector (Deressa *et al.* 2010). The changes or modifications in agricultural practices act as adaptation strategies in agriculture to climate change (IPCC 2014). As the developed and developing countries are still at loggerheads regarding whom to bear the responsibility for reducing GHGs, there is an urgent need to explore suitable adaptation strategies which make ecosystem more resilient to absorb shocks due to climate change (Boomiraj *et al.* 2010). In doing so, one must take into account local community's understanding of climate change, because even though climate change is a global phenomenon, adaptation is site specific (Lema and Majula 2009). Hence, better understanding of farmer's perceptions about climate change, its impact on agriculture production, existing adaptation technologies and factors influencing in adopting them is the need of the hour to develop policies and programs that aimed in promoting successful adaptation in agricultural sector (Chaudary *et al.* 2011). Keeping in view these issues, the present study was carried out on the farmers' perceptions, adaptation of improved technologies under varying climatic conditions in drylands of north Karnataka with high vulnerability index to climate change (Rao *et al.* 2013).

MATERIALS AND METHODS

Present study was carried out in (16° 11' 12.23" N latitude and 75° 41' 46.10" E longitude) districts located under northern dry zone of Karnataka (4.78 Mha area) during 2014–17.The mean annual rainfall of Vijayapura and Bagalkot districts ranges from 464.5–785.7 mm with 52% of annual rainfall received during *rabi*. This zone

Present address: [1]ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Ballari, Karnataka; [2]University of Agricultural Sciences, Dharwad, Karnataka; [3]ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan. *Corresponding author e-mail: ravi.dupdal@gmail.com.

receives low annual unimodal rainfall with mostly medium to deep black soils and has diversified cropping pattern. The primary data was collected from 240 farm households using multi-stage random sampling technique during 2016 and 2017.We selected Vijayapura and Bagalkot districts based on high vulnerability index to climate change in northern Karnataka (Rao *et al.* 2013). Later in each district two talukas i.e. Vijayapura and Sindagi in Vijayapura district and Bagalkot and Hungund in Bagalkot district were selected in consultation with respective Joint Directors of Agriculture (JDAs) who is heading Agriculture Department at district level for primary data collection. In each taluka we selected randomly two villages in consultation with respective Agriculture Officers (AO) heading taluka. Hittinahalli and Jumnal villages in Vijayapura taluka, Devarahippargi and Bommanjogi in Sindagi taluka; Bevoor and Hallur in Bagalkot taluka and Hirebadawadgi and Bannihatti in Hungund taluka were selected for our study. Further in each village, we selected 30 farmers thus totalling the sample size to 240 households for our study.

Statistical tools: The Garret Ranking Technique was employed to identify and rank various adaptation technologies adopted by the farmers. Garrett's formula for converting normal rank into per cent was given by:

$$\text{Per cent position} = 100 \times (R_{ij} - 0.5) / N_j$$

where, R_{ij} = Rank given for i^{th}factor by j^{th} individual; N_j = Number of factors ranked by j^{th} individual.

Binary Logit Model was employed to analyse the factors influencing the farmers to adopt various adaptation technologies to overcome impact of climate change. In order to determine whether farmers adopted technologies to mitigate the climate change, a probability model is used where the binary dependent variable is a dummy for undertaking any adaptation at all (i.e. Y_i has only two possible values 1 or 0, for either adapting or non-adapting to climate change). Thus,

$$Y_i = X_i \alpha + e_i$$

It is assumed that the probability of observing farmer "i" undertaking any adaptation at all (Y_i=1) depends on a vector of independent variables (X_i), unknown parameters (α), and the stochastic error term (e_i).The probability of observing farmer "i" undertaking any adaptation at all, $P(Y_i = 1/X_i)$ has empirically been modeled as a function of independent variables such as age, education, farming experience, family size, social participation, farm holding size, access to irrigation, livestock ownership, off-farm occupation and access to credit.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondent farm households: In the demographic composition old aged farmers with the average age being 57 with 36 years of farming experience were higher. These farmers have high farming experience and knowledge about farming and associated risks especially under climate change situations.The education of farmers had direct implication on technology adoption and its usage with one-third of farmers each categorized as illiterates, primary education and higher school education. The size of family represents the labour endowment. Average size of family members in each household was five persons and about 19% farmers have associated themselves with one or the other social organizations.Nearly 64% of farmers irrigate the crops from bore wells or open wells in order to sustain crop yields under climate change situations. Keeping agriculture as main occupation, over 45% of farmers are engaged in other off farm activities like small businesses and agricultural labour. About 53% farmers availed institutional credit for purchase of inputs like seeds, fertilizers and pesticides (Varadan and Kumar 2014).

Farmers' perception about varying climatic conditions: Nearly seventy-five percent farmers perceived climatic variability in terms of different meteorological indicators. Decreased total rainfall and its ill distribution with prolonged dry spells during cropping season drastically reduced crop yields as perceived by 70% of farmers. About 48% farmers perceived that increase in temperature was significant since last one or two decades. Frequent failure of monsoon was experienced by 35% of farmers while 33% of farmers felt that water stress and water shortage persisted especially during summer due to lower and ill distribution of rainfall. Delayed onset of monsoon was perceived by 13% farmers. The results of this study were in accordance with the earlier observations of increased temperature, delayed onset of monsoon, intermittent dry spells and decreasing soil moisture as the critical factors affecting crop yields in Kancheepuram district of Tamil Nadu (Dhanya and Ramachandran 2016).

Perceived impact of climate variability on agriculture: Nearly 81% of farmers reported that climate variability has adversely affected their farming. About 74% of farmers opined that decrease in rainfall and its ill distribution has produced lower crop yields in the region. Further 61% of farmers revealed that climate change has resulted in frequent crop failure while 47% of farmers observed decline in water level in bore wells and open wells. Nearly 28% of farmers experienced more pest and disease incidence due to climate variability, while 25% of farmers felt the emergence of new pest and diseases in the region. Further, 21% farmers experienced decline in fodder availability that further lead to lower livestock productivity as observed by 19% of farmers. Similar results of decline in ground water table, increase in soil salinity, uneven distribution of rainfall, increase in disease infestations as a result of climate change that finally resulted in crop failure with lower crop yields and migration of men and cattle in search of livelihood were also Rao *et al.* (2018).

Coping mechanism and adaptation strategies to varying climatic conditions: The farm management strategies like crop diversification with short duration crops like groundnut, pearl millet and cowpea and horticulture crops i.e. grapes, pomegranate and citrus fruits like lime replaced the traditional crops like cotton and sorghum in Vijayapura

Table 1 Coping mechanism and adaptation strategies to varying climatic conditions

Farm management strategies				
Strategies/coping mechanism	Vijayapura district		Bagalkot district	
	Mean Garrett Score	Rank	Mean Garrett Score	Rank
Crop diversification	95.45	I	66.34	IV
Inter/mixed cropping	77.42	II	86.56	I
Contingent cropping	11.97	IX	21.45	X
Alternate cropping	64.09	III	63.12	V
Widening irrigation intervals	11.14	X	31.56	IX
Manipulating sowing date	32.42	VIII	79.50	II
Reducing fertilizer application	47.58	VI	33.27	VIII
Drought and heat tolerant varieties	60.91	IV	50.00	VII
Water conservation practices	56.52	V	73.15	III
Dry sowing	34.09	VII	57.20	VI
Income management strategies				
Remittance	-	-	23.12	IX
Borrowing from money lenders	69.50	II	44.67	VI
Borrowing from friends and relatives	57.70	III	65.69	II
Crop Insurance policies	34.40	VII	36.80	VII
Government relief funds	45.36	V	66.20	I
Sale of livestock	38.67	VI	52.50	IV
Migration to urban areas	55.24	IV	49.00	V
Non-farm employment	70.35	I	59.36	III
Mortgage loan on gold/jewellery	30.05	VIII	25.28	VIII

district and also mixed/intercropping of pigeonpea+pearl millet and pigeonpea+groundnut were adopted to sustain crop yields and income of the farmers (Table 1). Farmers also cultivated alternate crops like tomato, brinjal and chilli with adoption of rainwater conservation measures and available bore water as protective irrigation to fetch higher income. Farmers also cultivated drought and heat tolerant crop varieties to combat the climate change and sustain crop yields. In addition, farmers followed the soil and rainwater conservation measures like bunding, farm ponds to conserve the rainwater *in situ* there by reducing soil loss and increasing the profile soil moisture for better crop growth. Adoption of improved crop management practices including soil and rainwater conservation practices by the farmers as per the weather based agromet advisory services under changing climatic conditions produced greater yields and reaped higher economic benefits as earlier reported by Dupdal *et al.* (2020).

The farm management strategies practiced by Bagalkot farmers were mixed/inter cropping system of sorghum+pigeonpea, groundnut+sorghum and chickpea+sorghum with timely sowing of crops immediately after onset of monsoon produced higher yields and income thus combating the climate change. Further, adoption of soil and rainwater conservation practices with crop diversification produced greater crop yields. Ravi Shankar *et al.* (2013) also opined that buying insurance, changing planting dates of groundnut, intercropping with redgram, construction of water harvesting structures, cultivation with early maturing and drought resistant/tolerant varieties were the major adaptation measures practiced by farmers to mitigate climate change and sustain crop yields with greater income in Anantapur district of Andhra Pradesh.

Farmers also adopted various income management strategies to sustain their livelihood during adverse climatic situations. In Vijayapura district, non-farm employment opportunity was the predominant strategy adopted by majority of farmers (Table 1). Farmers borrowed loans from money lenders, friends and relatives. In addition, farmers also migrated to cities like Mumbai, Hyderabad and Pune in search of life sustaining employment and daily wage earning in unorganized sectors such as construction industry, mines and quarries, domestic works, street vending, rickshaw pulling especially during drought years. Migrate as construction labour if monsoon fails, particularly in rainfed areas of the district is another common practice (Ravi Shankar *et al.* 2013). The non-agriculture secondary enterprises contributed to the livelihoods and annual incomes of 60% pastoralist households in arid *Banni* grasslands of Gujarat (Manjunatha *et al.* 2019).

Farmers in Bagalkot district were highly dependent on government relief funds followed by loans from friends and relatives and non-farm employment opportunities (Table 1). Dupdal and Patil (2017) also reported that government relief measures at the time of natural calamity help in reducing risks in agriculture.

Factors influencing adoption of adaptation strategies against climate variability: The socio-economic characteristics of the farmers influenced the adoption of different adaptation strategies. The results of the logit analysis revealed that age of the farmer, access to irrigation, education level, farming experience, social participation, farm holding size, livestock possession and institutional credit significantly influenced adoption (Table 2). The elderly farmers with more experience in farming adopted more as compared to young farmers. Similarly, access to irrigation provide sopportunity for farmers to go for multiple cropping with efficient utilization of farm resources. Livestock possession is another important component in dryland agriculture providing additional income to the farmers. Education level of farmers, farm holding size, institutional credit and social participation were significantly affecting the adoption. The results further showed that probability of adaptation to climate change is higher with small farm sizes and lower with large farm sizes since expenditure incurred in adaptation i.e. expenditure on irrigation facilities, improved seeds and fertilizer for large farm sizes were more expensive as compared to small farm size (Fosu-Mensah *et al.* 2012, Ndamani and Watanabe 2016).

Constraints experienced by farmers in adoption to

Table 2 Factors influencing adoption of adaptation strategies by farm households

Variable	Co-efficient	Standard error	p-value
Constant	2.857	3.231	0.859
Age	0.081	0.019	0.003***
Education	1.304	0.482	0.042**
Family size	-0.439	0.540	0.147
Farming experience	0.100	0.145	0.008***
Social participation	1.823	0.367	0.009***
Farm holding size	-0.042	0.035	0.001***
Livestock ownership	-0.720	0.013	0.092*
Irrigation	1.388	0.032	0.002***
Institutional credit	-3.588	1.013	0.001***
Off-farm occupation	1.353	0.555	0.756
Chi-square value		125.059***	

Note: *, ** and *** denote significance at 10%, 5% and 1%, respectively.

climatic variability: The important constraints encountered in adoption of adaptation strategies to mitigate climatic adversities were lack of timely availability of weather forecast information particularly the rainfall, temperature and relative humidity as expressed by 78% of farmers. Due to non-availability of weather information, there was ambiguity in farmers in choosing appropriate crops. Around 59% of farmers expressed shortage of water for irrigation, as it is a critical input for crop selection/growth and ultimately crop yields and income. In addition, 51% and 46% of farmers experienced lack of timely availability of farm inputs such as quality seeds of a desired variety, fertilizers and lack of timely availability of credit, respectively.

The results of this study revealed that 70% of farmers experienced changing climatic condition in the form of decreasing rainfall, increasing temperature, frequent failure of monsoon and water stress conditions. Farmers perceived the effects of climate change in agriculture in the form of decline in crop yields, frequent crop failure, decline in water levels in bore wells and open wells and increased emergence of pest and diseases. However, farmers exhibited resilience to climate change through adaptation strategies like crop diversification, inter/mixed cropping, manipulating sowing date, selection of alternate cropping and drought tolerant varieties, adoption of soil and rainwater conservation measures/structures. The government's role in enhancing access and timely delivery of weather forecasts, critical farm inputs and crop insurance mechanisms would enhance farmers' resilience to climate change.

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